

PROACT FACT SHEET



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Phytoremediation

Introduction

The Air Force has developed the Environmental Restoration Program to identify, investigate, and cleanup environmental contamination associated with past activities. There are various technologies available to address remediation of contaminated sites, one such method is phytoremediation.

Phytoremediation is a biological process in which living plants are used to remove, accumulate, degrade, or contain environmental contaminants. This passive remediation technique is based on the natural ability of vegetation to utilize nutrients, which are transported by capillary action from the soil and groundwater through a plant's root system. The use of a plant's own biological mechanisms to contain and reduce concentrations of inorganic and organic contaminants in soils, sediments, and groundwater is a slow process relying on a plant's growth rate. However, with advances in biological, chemical, and engineering technologies, phytoremediation has the potential to serve as a sustained, ecologically sound method to remediate contaminated soil and groundwater.

Biological Mechanisms

In addition to transporting nutrients, certain plants are capable of transporting environmental pollutants such as metals, radionuclides, chlorinated solvents, petroleum hydrocarbons, and ammunition wastes through biological means.

- **Hydraulic Control or phytohydraulics** - the use of a plant's root system to contain contaminant migration and infiltration by creating a hydraulic barrier, which also provides a vegetative cover that reduces contaminant exposure.
- **Phytoextraction or phytoaccumulation** - the use of a plant's root system to extract and transport inorganic contaminants such as metals or radionuclides from soils, which accumulate in aboveground plant tissue.

- **Rhizofiltration** - the use of a plant's root system to absorb inorganic contaminants dissolved in groundwater, which accumulate in a plant's roots.
- **Phytostabilization** - the use of a plant's root system to precipitate and absorb inorganic contaminants from soils and groundwater, which accumulate within the plant's roots.
- **Phytodegradation or phytotransformation** - the use of a plant's root system to extract organic contaminants such as solvents, pesticide and herbicide residues, and hydrocarbons from soils and groundwater, which degrade within the plant.
- **Rhizodegradation, also known as rhizosphere biodegradation, phytostimulation, or plant-assisted bioremediation** - is a result of a plant's root system releasing chemicals that enhance organic contaminant biodegradation by soil microorganisms.
- **Phytovolatilization** - the use of a plant's root system to extract and transport organic contaminants from groundwater to the leaves that transpire, evaporate, or volatilize the contaminants into the atmosphere.

Site & Plant Selection

Phytoremediation is not applicable at all contaminated sites. This remediation technique requires a large land area that has low to moderate contaminant concentrations within shallow soils and water table. Generally, phytoremediation is limited to within 3 feet of the surface for contaminated soils and within 10 feet of the surface for contaminated groundwater.

Aside from site conditions, phytoremediation is dependent on selecting the right plant for contaminants. Plants are complex systems whose biological mechanisms are dependent on various environmental factors; however, a fundamental trait in selecting a plant for phytoremediation is an expansive root system. Other plant selection parameters include the rate of plant and root growth, whether a plant freely transpires, and if a plant is suitable for the local environment and the contaminant of concern.

Fate of Contaminants

Once plants extract environmental contaminants, these contaminants are either broken down by the plant into non-hazardous substances or concentrated within plant tissues. Concentration of contaminants in plant material gives rise to the possibility of animals and insects consuming the contaminated material thereby introducing contaminants into the food chain.

To date, there is limited information regarding this issue due to the complex biological mechanisms involved. However, remedial sites implementing phytoremediation are taking measures to restrict grazing animals and birds by erecting fences and overhead nets. In addition, biodegradable pesticides are used to eliminate rodents and insects, and plants are harvested prior to seeding or flowering, which limits the availability of food.

Harvesting/Disposal

To sustain viable plant populations and operation of the system, plant material must occasionally be harvested. Harvested plant tissue, which has metabolized and accumulated environmental contaminants requires testing to determine if the tissue is hazardous. If testing confirms harvested material has metabolized the contaminant into non-hazardous substances, the plant material can be mulched or composted and reused on site. However, if the plant has accumulated contaminants and testing indicates plant tissues are hazardous, then those tissues which are hazardous (roots, stems, leaves, etc.) must be disposed of as such. Although harvested plant material may be considered hazardous, phytoremediation is a cost effective remediation method, which causes little environmental disturbance while successfully reducing soil and groundwater contaminants.

Additional Information...

- Contact PROACT at DSN 240-4240 or visit us at <http://www.afcee.brooks.af.mil/pro-act/PRO-ACThome.asp>.
- The Environmental Restoration Division, Air Force Center for Environmental Excellence (HQ AFCEE/ER), DSN 240-3383 or <http://www.afcee.brooks.af.mil/products/rpo/default.asp>.
- The Technology Innovation Office, EPA, website which provides information on remediation treatment technologies at <http://www.epa.gov/tio/>.

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